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458.9
R31
#48

ARS 42-48
APRIL 1961

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

SEED LOSSES IN HARVESTING SOME GRASS AND LEGUME CROPS
IN THE WILLAMETTE VALLEY, OREGON, 1953-1954^{1/}

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INTRODUCTION

Heavy losses frequently occur in harvesting some grass and legume seed because of the physical characteristics of the crop or lack of suitable harvesting machinery. During 1953 and 1954, 65 tests were made to measure losses and to determine where they occur, as a basis for improving harvesting machinery and methods. Such tests were made of seed harvesting operations on farms in the Willamette Valley of Oregon.

The Oregon Agricultural Seed Advisory Committee made the selection of crops to be covered in the survey, and the list included crimson clover, Alta fescue, hairy vetch, bentgrass, and subterranean clover. Harvesting by the windrow and combine method and by direct combining were studied for all of these crops except subterranean clover. No farmer was found who used the direct combine method on this clover. The direct method is illustrated in Figure 1 and the windrow method in Figure 2.

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- ^{1/} Cooperative investigations of the Agricultural Engineering Research Division, Agricultural Research Service, U. S. Department of Agriculture and Oregon Agricultural Experiment Station, Corvallis, Oregon.
- ^{2/} Agricultural Engineers and Consultant, respectively, Agricultural Engineering Research Division, Agricultural Research Service, U. S. Department of Agriculture.



Figure 1. Self-propelled combine cutting and threshing Alta Fescue in one operation.



Figure 2. Tractor drawn combine with attachment for picking up and threshing the crop from windrows.

The data sheets were divided into five sections: (1) General information such as the name and address of the farmer, the date, time of day the test was run, relative humidity, wind direction and velocity, the method and equipment used in the harvesting operation. (2) Crop information such as variety, rows or broadcast, stage of maturity, and height of cut. (3) Type, make, model of machine; auxiliary attachments, types of threshing cylinders, speeds and settings of the component parts, such as the cylinder and concave, the straw walker, shoe and fan; forward speed, and rate of harvest. (4) Seed sample record including test and sample number, and where it originated. (5) Moisture information such as location, or stage of the operation where the sample was taken, whether straw or seed, from windrowing or combining operation, the can numbers, and the replication. (See data sheet page 18.)

FIELD PROCEDURE

Preharvest Samples

Requirements for the test area included uniform crop, average weed infestation, straight rows and level land. Two replications of the complete test were made in each farmer's field. Five preharvest samples were taken for each replication to measure standing crop seed yield, germination and preharvest shatter. Two poles 100 feet apart were placed 25 to 50 feet in from the edge of the field. The line between the poles was parallel to the edge of the field and marked at 20-foot intervals. A sample was then taken near each of these five marks.

In obtaining the preharvest samples for yield, germination and shatter an initial 4-foot straight line cut was made in the crop with a hand-operated grass shears. The cut was made vertically, and the cut material pulled away from one side of the cut so as to leave a vertical wall in the crop. A three-sided sampling frame of 1/10,000 acre area was inserted into the vertical wall at the ground line, as illustrated in Figure 3. Vertical side and back cuts were made by cutting all material straight up from the inside edge of the frame. All seed hanging outside of the frame was carefully made to fall outside, leaving all material within the vertical cuts inside the frame. Care was taken not to cut through seed. Seed heads or individual florets were pushed either in or out, depending on where the majority of the seed was originally.



Figure 3. Three-sided sampling frame of 1/10,000 acre area in use for obtaining preharvest yield, seed germination and shatter.

For tall grasses, the method of selecting seed to be in the test frame was slightly different. The initial cut was made by carefully separating the stems on either side of a 4-foot long straight line and pulling the heads of those growing on one side apart from those growing on the other. Likewise, the side and back cuts were made in the same manner after inserting the sampling frame.

A small canvas was spread on the ground next to one side of the sampling frame to receive the seed cut from the standing crop. The cut was started on the opposite side from the canvas and all plants severed below the seed heads. As the clipping proceeded the sample was pushed and rolled over onto the canvas. The material on the canvas was sacked and marked as the sample from which to determine standing seed yield and germination. The three-sided frame was then replaced with a four-sided frame of the same dimensions for obtaining shatter loss.

The stems standing within the frame were cut close to the ground and the sample area raked with a hand rake. All material was gathered and sifted on a one-half inch square wire mesh screen to let the loose seed fall back to the ground. The sample area was then carefully vacuumed with a household size vacuum cleaner to recover all seed left on the ground. (Figure 4.) The sample from the vacuum cleaner was sacked and marked to indicate preharvest shatter. In addition, seed was stripped or picked by hand from the stems at random in the test area and placed in an air-tight can for moisture determination. Stems, with seed and roots cut off, were placed in another can for moisture determination.



Figure 4. Recovering preharvest shattered seed from sample area with household size vacuum cleaner.

After windrowing and just prior to combining, a measure of the mowing and windrowing shatter was obtained by carefully separating a windrow in the test area and rolling one end of it back several feet. At 1/2000 acre area adjustable sampling frame was adjusted to have a length equal to the width of cut of the mower and placed in the open area of the windrow. The straw within the frame was raked, sifted, and discarded. The 1/2000 acre area was carefully vacuumed with a hand vacuum cleaner and the sample sacked and marked to indicate preharvest, plus windrowing shatter. (Figure 5.)



Figure 5. Obtaining preharvest shatter and windrow shatter prior to threshing from windrows.

At the time of threshing, seed was stripped and picked from different parts of the windrow when applicable and placed in air-tight cans for moisture determination.

THRESHING SAMPLES

During the farmer's combining operation, direct or windrow, a two canvas test was performed twice to measure the seed losses and damages, patterned in part after the technique reported in similar studies for other crops. ^{3/}

^{3/} Bunelle, P. R., Jones, L. G., and Kepner, R. A. Small Seed Legume Harvesting Clover and Alfalfa Seed Threshing Losses Minimized by Minor Modifications and Adjustments of Present Machines. Calif. Agri. 6(9), Nov.-Dec.1952.

McCuen, G. W., and Silver, E. A. Combine Harvester Investigations. Ohio Agri. Expt. Sta. Bul. 643, July 1943.

In the selected test area a 1/100 acre plot was established. The length of the test plot was determined by dividing the width of cut by the harvester into 435.6 square feet. A flagged stake was set approximately 10 feet to the side of the plot so that the combine could pass without striking it. The calculated distance was measured parallel to the area to be harvested and a second flagged stake set. The farmer's equipment and operators were used in the test and the combine adjustments were not changed.

In making a test of threshing from the windrow or standing crop the four-man crew, equipped with the necessary containers and the two canvases, got into position as the combine approached the test section. The machine was usually stopped around 200 feet before it reached the first or starting flag, and one of the crew members was stationed in the grain bin with a whistle for signaling and a container to catch the material being discharged. The combine operator was instructed to take a full swath cut and operate at his normal forward speed, and to keep going until he was well past the stop flag. As the machine traveled over the 200-foot distance all the functional parts of the combine became fully loaded before it reached the start flag. The signalman located in the grain bin blew his whistle as he came in line with the start flag. Simultaneously, at the whistle, a container was placed under the grain discharge and the two canvases pulled into place at the rear of the combine, one under the rack to catch the straw discharge, and the other under the shoe-sieve-discharge to catch the chaff. (Figure 6)



Figure 6. Two canvas method in use for determining threshing losses.

As the signalman came in line with the stop flag, the whistle was sounded again and the container and canvases removed. Each discharge was sacked separately and marked, indicating the test number, the sample, and the replication. (Figure 7)



Figure 7. Collecting straw from canvas at end of test.

Seed moisture samples were taken from the grain bin and straw moisture from the material on the straw rack canvas.

After completing the two-canvas test, a third suction sample was taken from within the test area to gain a measure of total shatter. The same 1/2000 acre area frame, used under the windrow, was used in sampling the area over which the canvases had passed. The same procedure of racking, sifting, vacuuming, and sacking followed. The sample was marked to indicate total shatter or preharvest, plus windrowing, plus pick-up shatter. All samples were then trucked to the seed processing laboratory for analyzation. (Figure 8)



Figure 8. Samples from tests ready for hauling to seed laboratory.

LABORATORY PROCESSING

Harvest sample analyzing was first attempted by the use of air screen and other cleaners. The accuracy of separating broken, unthreshed, and whole seed from trash was not great enough. Therefore, a sub-sampling method was devised with the help of the Oregon State College Seed Testing Laboratory.

In the sub-sampling method, the material was first scalped over large hole screen that easily let all of the whole seed through. (Figure 9) Grass seed attached to stems that rode over the screens was thoroughly re-threshed in a small stationary threshing machine, then re-run over the scalping screen. The free seed thus recovered was classified as unthreshed seed. Many of the whole seed portion of the samples with dirt and fine material were then run through wringer rolls to crush clods, and screened on fine screens to save all whole seed but to sift out the dust. The object of scalping was to reduce the volume without losing any seed and to remove the large particles so that the remaining seed material would flow through a chaffy grass divider.



Figure 9. Screening or scalping was the first processing operation in the seed laboratory.

To obtain an equilibrium moisture content the samples were next conditioned for one week in a room of constant temperature and humidity and then weighed. A sub-sample of from 10 to 25 grams, which was representative of the whole, was divided from each sample by a chaffy grass divider. (Figure 10) Seed in the sub-sample were



Figure 10. Chaffy grass divider.

separated by hand methods. The sample was usually hand-screened to separate large chaff and unthreshed seed from whole and broken seed. The unthreshed seed portion was hand threshed on a rubber-faced rubber board, then re-screened to separate particles larger and smaller than the whole seed which was marked "unthreshed". (Figure 11) Usually

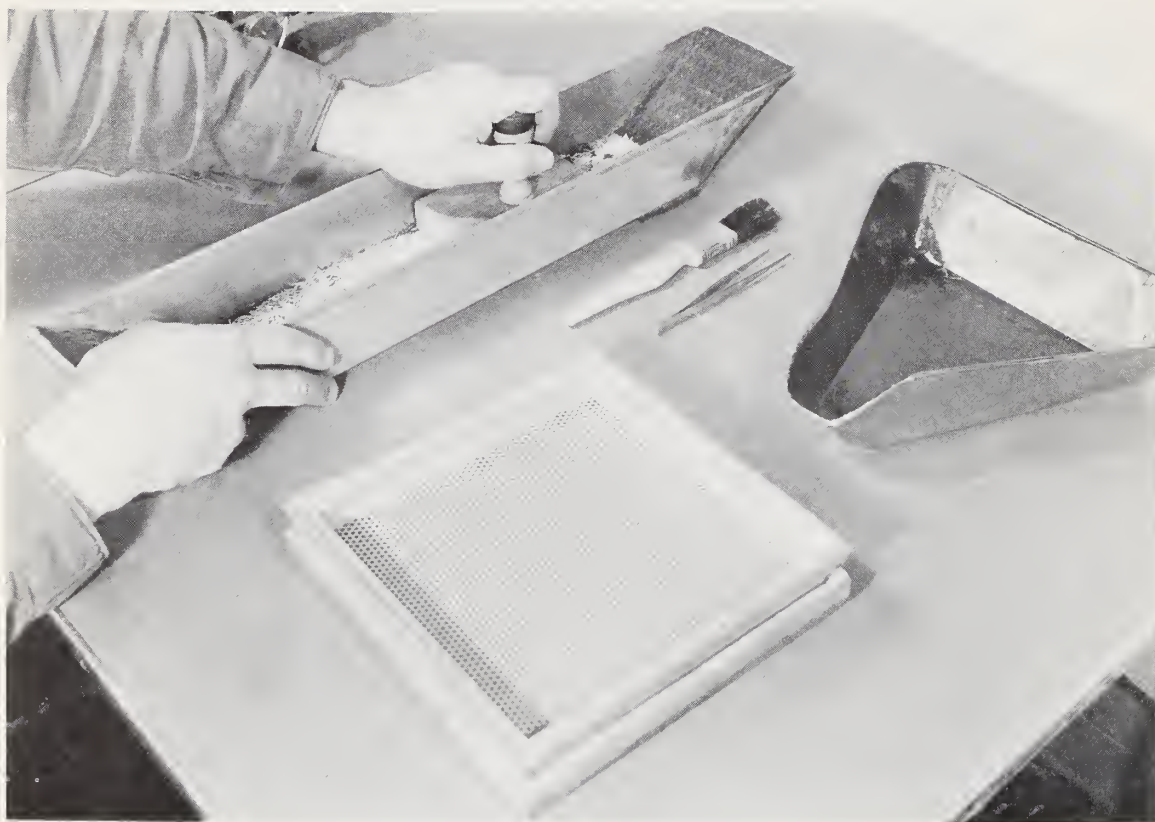


Figure 11. Hand threshing.

Unthreshed seed was further separated from light trash or empty seed florets by an air separation on a South Dakota blower. The original fraction of whole and broken seed was screened on a fine screen that would eliminate dust but retain broken seed particles. Separation was further made by differential blowing on a pneumatic seed separator. Final separation and inspection of all samples were made on the analyzing board with hand lens and tweezers. (Figure 12)

Combine discharge samples were separated into the four fractions of whole seed, unthreshed seed, broken seed, and trash, while yield and shatter samples were separated into the two fractions of whole seed and trash.



Figure 12. Final separation and inspection of samples in determining seed losses in harvesting some grass and legume crops.

Each fraction was weighed to 0.001 gram, and percentages calculated based on the total weight of the sub-sample. These percentages were applied to the original weight of scalped material together with the appropriate constant, depending on the size and number of the original sample areas, to give figures in pounds per acre.

Unthreshed or broken seed found in any of the combine discharge samples was considered cylinder loss. Whole threshed seed passing over the rack was considered rack loss, and whole threshed seed going over the shoe was classified as shoe loss.

All moisture determinations of seed and straw were made by the oven method and calculated on both the wet and dry basis.

Seed germination was made by the seed analysts in the Oregon State College Seed Testing Laboratory who used official standards. Germination percentages were applied to the weight figures to give pure live seed in pounds per acre. The average losses occurring for the crop harvested by the direct combine and windrow-combine methods are shown in table 1.

Table 1. Average losses in harvesting some grass and legume crops in the Willamette Valley of Oregon during 1953 and 1954.

| Source of loss | Crimson clover | | | Alta fescue | | | Hairy vetch | | | Bentgrass ^{1/} | | Subterranean clover | |
|----------------------|--------------------|-------------------------------|--|--------------------|-------------------------------|--|--------------------|-------------------------------|--|-------------------------|-------------------------------|---------------------|-------------------------------|
| | Combine Percent | Windrow combine Percent | | Combine Percent | Windrow combine Percent | | Combine Percent | Windrow combine Percent | | Combine Percent | Windrow combine Percent | Combine Percent | Windrow combine Percent |
| Pre-Harvest | | | | | | | | | | | | | |
| Germination | 9.5 | 2.8 | | 4.4 | 8.2 | | 16.0 | 12.7 | | 4.3 | 6.5 | 3.0 | |
| Shattering | 24.6 | 4.7 | | 19.5 | 2.8 | | 22.2 | 7.2 | | --- | --- | --- | |
| Crop Cutting | | | | | | | | | | | | | |
| Windrow shattering | --- | 22.7 | | --- | 14.6 | | --- | 12.2 | | --- | --- | 48.4 ^{2/} | |
| Pick-up shattering | --- | 4.0 | | --- | 7.8 | | --- | 5.6 | | --- | --- | 19.7 | |
| Cutterbar shattering | --- | --- | | 10.3 | --- | | 12.8 | --- | | --- | --- | --- | |
| Threshing | | | | | | | | | | | | | |
| Rack | 7.2 | 2.4 | | 1.0 | .5 | | 2.5 | 3.3 | | --- | --- | .8 | |
| Unthreshed | 12.7 | 23.4 | | 1.0 | .3 | | 1.4 | 2.6 | | --- | --- | 3.2 | |
| Broken seed | 1.9 | 2.2 | | .0 | .0 | | 8.7 | 2.4 | | --- | --- | 1.2 | |
| Shoe | 1.9 | .7 | | .4 | 2.7 | | 7.0 | 1.2 | | --- | --- | .6 | |
| Sifting | .1 | 0 | | 0 | 0 | | 0 | 0 | | --- | --- | 0 | |
| Germination | 5.3 | 3.7 | | 1.6 | -2.3 | | -.1 | -.2 | | 1.1 | 1.3 | .5 | |
| TOTALS | 63.2 | 66.6 | | 38.2 | 34.6 | | 70.5 | 47.0 | | 19.0 | 25.8 | 77.4 | |

^{1/} See page 16 for losses in "Source of Loss" catagories for one farm.

^{2/} Seed on plant below cutterbar range.

Detailed data of individual tests are not included because of the large volume of material involved and the wide variations in machine, field, and crop conditions. For instance, from the 11 tests in windrowed crimson clover, the date of windrowing varied from June 24 to July 21; date of combining varied from July 12 to August 2; three types of cylinders were encountered, spike-tooth, rasp bar, and rubber angle bar; cylinder speed varied from 2,880 to 7,287 ft./min.; cylinder clearance from 1/16 inch to 1/2 inch; forward speed from 0.63 to 2.17 mi./hr.; rate of harvest from 0.35 to 1.65 acres/hr.; grain bin material - 410 to 1,190 lb./acre; straw rack material from 1,300 to 5,012 lb./acre; shoe material from 600 to 2,737 lb./acre; total material through combine - 2,010 to 7,275 lb./acre; field seed moisture from 6.0 to 11.6 percent wet basis; field straw moisture 7.8 to 59.37 percent wet basis; and grain bin seed moisture 6.7 to 17.7 percent wet basis.

LOSSES

The combine-harvester-thresher was designed originally for cereal grain.^{4/} Generally, these crops stand erect, have uniform moisture, and are easy to thresh. Some grasses have extremely small seed and some have awns and appendages which hinder in threshing and cleaning; some legumes shatter badly. Consequently, seed losses in harvesting grasses and small legumes are much higher than for cereals.^{5/}

Crimson Clover

Crimson clover shatter consisted mostly of unthreshed seeds (seeds still in the hull) which had dropped to the ground. Shattering takes place very easily when the crop is mature and dry. Threshing includes both separating seed in the hull from the stem and separating seeds from their hulls. The latter is the difficult part, especially if the seed is immature or moist.

Preharvest shattering of direct combined crimson clover was the largest loss at 24.6 percent since the crop is left standing longer in the field to mature and dry. The two largest losses with the windrow-combine method were windrow shatter at 22.7 percent and unthreshed seed

^{4/} Reynoldson, L. A., Keefer, R. S., Martin, J. R., and Humphries, W. R., The Combined Harvester-Thresher in the Great Plains, U.S.D.A. Tech. Bul. No. 70, Feb. 1928.

^{5/} Hurst, W. M., and Humphries, W. R., Harvesting with Combine - U.S.D.A. Farmer Bul. No. 1761, Oct. 1936, Rev. Mar. 1947.

at 23.4 percent of the total crop. Apparently mowing, windrowing, and curing in the windrow were performed on the average at a late stage of maturity when the seed shattered easily. Also, threshing action was not severe enough as indicated by high unthreshed seed loss, low broken seed loss, and low damage measured by threshing germination loss.

Very few growers of crimson clover harvest their crop direct in the Willamette Valley; in fact, the data for direct combining represents only one grower each year (as compared to six growers the first year and five the second for the windrow-combine method). The smaller total loss by direct combining of 63.2 percent compared to 66.6 percent for windrow and combining is judged to be misleading because of the lack of replication each year and the fact that tests in subsequent years have consistently shown the windrow-combine method to be better.

Alta Fescue

Preharvest shattering and cutterbar shattering made up the bulk of losses in harvesting Alta fescue with the direct combine method, 19.5 and 10.3 percent, respectively. (Table 1) The preharvest shattering was only 2.8 percent with the windrow-combine method but 14.6 percent of the crop was lost by shattering from the windrow. The end results were 38.2 percent total loss with the direct method and 34.6 percent with the windrow method.

Hairy Vetch

The seed pods of hairy vetch crack open as they mature and many of the seed may fall to the ground especially if the harvest is delayed. For this reason losses are less with the windrow method than with direct combining because the crop is cut on the green side in windrowing. Table 1 shows 70.5 percent loss with the combine and 47.0 percent with the windrow method.

Bentgrass

Losses in harvesting bentgrass were lower than for other crops, 19.0 percent with the combine and 25.8 percent with the windrow-combine method. Only germination and total loss are shown for the two methods in table 1. Labor was not available for analyzing the samples necessary for determining losses under each category. The seed are extremely small and very tedious hand work is required in making the separation. Complete data were obtained, however, from samples from one farm using the combine method. These records were from one of the best farm operators growing bentgrass and the total losses were considerably less than the average for all farms studied. The pre-harvesting loss

were 2.1 percent germination and 3.6 percent shattering. Under crop cutting the cutter bar loss was 0.3 percent. The threshing losses were 1.2 percent rack, 0.1 percent unthreshed, 0.4 percent broken seed, 0.3 percent shoe losses, and 1.3 percent germination loss making a total of 9.3 percent.

Subterranean Clover

In harvesting subterranean clover the big losses are shattering and seed pods too low for the cutter bar. The seed are produced very low on the plants and the seed pod may be found in cracks and crevasses below the surface of the field, hence the name subterranean. Because of the nature of the crop, neither the combine nor the windrow method are well suited. The average harvesting loss with the windrow-method was 77.4 percent. No farmer was found who used the direct combine method on this crop.

CONCLUSIONS

Losses in harvesting and threshing crimson clover, Alta fescue, hairy vetch, bentgrass, and subterranean clover during the 1953 and 1954 seasons in the Willamette Valley, Oregon, ranged from 19 percent for bentgrass to 77.4 percent for subterranean clover. These losses were higher than for such crops as wheat, oats, and soybeans. With the latter crops, and with the same methods and machines, seed losses associated with harvesting usually range from about 5 to 10 percent.

Studies of individual operators show that farmers can do much in reducing seed losses in harvesting some grass and legume crops. These include timely harvest, machine adjustments and selection of method, combine or windrow-combine.

SAMPLE

- 18 -

TEST NO. 110

SEED HARVESTING

DATA SHEET

I. GENERAL INFORMATION

NAME OF OWNER -----

ADDRESS Rt. 1 Corvallis, Oregon

DATE July 22, 1954 TIME OF DAY 4:00 - 6:00 P.M.

WEATHER CONDITIONS:

CLEAR / CLOUDY ----- PARTLY CLOUDY ----- REMARKS -----

WIND VELOCITY - FT./MIN. 1260 MI./HR. 14.3 DIRECTION NNE

DRY BULB TEMP - °F. 82 WET BULB TEMP. °F. 65 R.H.-% 39

METHOD OF HARVESTING:

DIRECT COMBINING ----- WINDROWING AND COMBINING /

OTHER -----

WIDTH OF CUT - FT. 4.8 WIDTH OF WINDROW - IN. 20" to 30"

SIZE OF SAMPLE FRAME - FT. -----

TYPE OF EQUIPMENT Drag Bar Winrower 5 ft

DATE OF WINDROWING June 29 DATE OF COMBINING July 22, 1954

WEATHER BETWEEN WINDROWING & COMBINING Cool - cloudy - rainy

REMARKS Winrows were turned for drying

II. CROP DATA

NAME OF CROP Crimson clover ROW SPACING -----

HEIGHT OF CROP - IN. 27 to 28 HEIGHT OF STUBBLE - IN. 3

STAGE OF MATURITY Over ripe when harvested. 25 acre field

planted fall 1953.

TEST NO. 110

III. MACHINE DATA

NAME Case

MODEL A-6 YEAR 1948 TRACTOR DRAWN / SELF-PROPELLED

CUTTING OR PICK-UP EQUIPMENT:

DIAMETER OF REEL-IN. SPEED OF REEL-RPM FLAX ROLLS

TYPE OF PICK-UP EQUIPMENT pick-up guards on sickle SPEED-RPM

TYPE OF FEED MECHANISM SPEED-RPM

THRESHING CYLINDER:

TYPE spike tooth CYLINDER SIZE-IN. 22"dia.28"long

SPEED-RPM 1150 FPM 6624 CLEARANCE-IN. 3/16 front 1/4 rear

TYPE OF TOOTH taper NO. OF BARS OR CONCAVES 6-rows-clover in rear one row plain in front

CONDITION OF CYLINDER Fair

SEPARATING:

STRAW RACK / STRAW WALKER SPEED-RPM 232

CLEANING:

CLEANING SHOE SPEED-RPM 232 CHAFFER SETTING-IN. 3/16 EXT.-IN. 3/4

SCREEN SIZE-IN. 1/16-1/8 TYPE adj. SPEED-RPM 425

FAN SPEED-RPM SETTING

REMARKS

TEST SPEED & CAPACITY DATA:

LENGTH OF RUN 91'

| | TIME OF RUN SECONDS | FORWARD SPEED MI./HR. | RATE OF HARVEST ACRES/HR. |
|------|------------------------|--------------------------|------------------------------|
| (1) | 93 | .67 | .39 |
| (2) | | | |
| AVG. | | | |

TEST NO. 110

IV. SEED YIELDS AND LOSSES:

| | (1) | (2) |
|---|---------|-----|
| A. STANDING SEED ----- NO. OF SAMPLES | 5 | |
| B. PRE-HARVEST SHATTER ----- NO. OF SAMPLES | 5 | |
| X. PRE-HARVEST & WINDROW SHATTER- NO. OF SAMPLES | 1 | |
| Z. WINDROWED SEED ----- NO. OF SAMPLES | 1 | |
| D. TOTAL SHATTER ----- NO. OF SAMPLES | 1 | |
| G&H. RACK MATERIAL ----- NO. OF SAMPLES | 6 sacks | |
| I. SHOE MATERIAL ----- NO. OF SAMPLES | 5 bags | |
| K. GRAIN BIN MATERIAL ----- ³ NO. OF SAMPLES | 1 bag | |

V. MOISTURE:

| | | MOISTURE | | | |
|---------------------|---------|-------------------------|-------------------------|------------------|-------------|
| | | DRY BASIS PERCENT | WET BASIS PERCENT | METER READING | TEMP. °F |
| MOWING & WINDROWING | CAN NO. | | | | |
| FIELD SEED (1) | 120 | 6.72 | | | |
| (2) | | | | | |
| AVG. | | | | | |
| FIELD STRAW (1) | 15 | 7.75 | | | |
| (2) | | | | | |
| AVG. | | | | | |
| COMBING | | | | | |
| FIELD SEED (1) | | | | | |
| (2) | | | | | |
| AVG. | | | | | |
| FIELD STRAW (1) | | | | | |
| (2) | | | | | |
| AVG. | | | | | |
| GRAIN BIN SEED (1) | 3 | 7.06 | | | |
| (2) | | | | | |
| AVG. | | | | | |

NOTES: _____

